How and why do we compare different sedimentary basins? Answer with reference to both comparing different types of basins, and comparing basins of the same type. What other geophysical feature follows a similar profile to a subsiding basin?

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Plan

- Introduction
- Reason for comparison
- Types of basin - based on creation mechanisms
- Comparison between the same type
- Comparisons made between different types
- Flexural basins

Essay

Introduction

Sedimentary basins provide us with a useful long-term depositional record of the geological history, and by exploring the nature and properties of the different sedimentary basins that are found around the world, we can gain an understanding of geological history via the application of our understanding of current geological processes on the rock record.

Basin types

Using a system based on the formational history of the basin, we can categorise basins with two axes. Primarily, the margin and tectonic setting it was created is used for classification:

- Foreland basins,
- Rift basins,
- Postrift and passive margin basins,
- Strike-Slip basins.

We are also able to apply a secondary axis in our classification, which categorises the basins based on the geophysical process that worked to create the basin:

- Flexural,
- Lithospheric stretching (isostatic effect),
- Lithospheric cooling (isostatic effect),
- Dynamic mantle.

[Diagram that shows types of basin]

Not all of these are possible or observed; however, with a combination of these, we can start to work out the difference between and within the groups of basins to help simplify our understanding of basin mechanics. With about 70% of the basins created since the Phanerozoic era being due to lithospheric extension, there is a large importance in distinguishing the geological history within basins of the same type. However, basins that form due to the flexure of the lithosphere and strike-slip mechanisms also play an essential role in our understanding.

Difference between basins of the same type

When comparing differences between basins of the same type, it becomes crucial to look at the finer details of the differences that would allow us to distinguish features common between the sedimentological history of basins.

We can create a geometric map of the basin by utilising data collected from bathymetry. Comparing basin size and geometry within the same type of basin helps us understand variations in subsidence patterns and sediment accommodation, which factors like local tectonics and sediment supply can influence. Then, with data from low-frequency sonar, it is possible to add a representative cross-section of the sediment formation. When this is further combined with data collected from boreholes, specific stratigraphy is able to be interpreted across a larger scale. This is particularly helpful, as once back calculations have been completed on the stratigraphy, considering the effects of compaction and lithospheric accommodation, it is possible to compare the depositional environments and rates between similar basins.

Another comparison that can be made of current basins is by comparing the evolution of the basin from early stage initiation through to developmental subsidence and infill. This sort of comparison allows for greater insights into the temporal and spatial evolution of sedimentary basins.

For example, useful comparisons between the East African Rift (EAR) and the Rhine Graben can provide an insight into extensional rifts due to the evolutionary stages that each is at. The EAR is an active continental rift representing an early stage of rifting, characterised by extensional tectonics and the initial phases of continental breakup. This compares to the Rhine Graben, which is a mature rift basin (formed in the Eocene) that has undergone significant extension and is in the later stages. This is reflected in several ways, most notably by geometry, with the EAR stretching from the Afar Triple Junction in the northeastern part of the rift to Mozambique in the south exhibiting a complex geometry with multiple branches. This contrasts with the Rhine Graben, which is a smaller and more well-defined rift basin with a length of around 350 kilometres and geometry that reflects the earlier stages of rifting and subsequent subsidence.

Differences between basins of different types

Arguably, the most important distinction between the basin types is the tectonic setting which formed the sedimentary basin. This can change over time. However, there are characteristic features that differ between the tectonic settings. For example, strike-slip basins are characterised by lateral motion and often have pull-apart or restraining geometries with the sediments, often including fault-related deposits and basin-fill sequences. This contrasts with the sedimentation in passive margin basins, where it is influenced by subsidence and sediment supply. Shelf, slope, and deep-sea environments are common, with the accumulation of marine sediments and the basin profile is often characterised by a gentle slope.

As shown, the tectonic setting can often play a large role in the sedimentation type formed. However, another key difference that can be compared between basins of different types is the source material that is deposited. For example, assessing the types and distribution of source rocks and reservoirs in each basin is essential for understanding its hydrocarbon and other natural resource potential. Also, comparing structural elements like faults, folds, and salt structures helps in understanding the basin's subsurface architecture, which can lead to crucial information for both resource exploration and assessing geological hazards.

For example, it is possible to compare the EAR basin (a rift basin) that was mentioned and the North Sea Basin (passive margin basin). The North Sea Basin exhibits a broad shelf, a gently sloping continental slope, and a deep central basin, which compares starkly with the EAR, which features elongated rift valleys, steep fault scarps, and associated volcanic structures. The different types of formation are also reflected in the sedimentation record, as the North Sea basin accumulates a mix of clastic sediments, including sands, silts, and muds, with a significant presence of marine fossils, which compares to the EAR, where the breakdown of the continental plate leads to volcanic rocks, alluvial deposits, and lake sediments contributing to the diverse sedimentary record.

Flexural basins

These basins form near regions of the lithosphere that have been loaded with a recent weight where the isostatic effects have not had a chance to re-equilibrate. For example, this is common near mountain ranges in response to the flexure of the lithosphere under the weight of the mountains. As the crust flexes downward, a basin is created where sediments accumulate. The subsidence in a flexural basin results from the crust's loading and unloading due to tectonic processes, similar to subsiding sedimentary basins.

Conclusion

In conclusion, delving into sedimentary basins allows us to decode Earth's geological history, providing practical insights for resource exploration and hazard assessment. Understanding the nuances of basin formation in different locations sheds light on the broader patterns of the rock record. This knowledge proves invaluable in predicting geological processes, assessing risks, and uncovering potential resources.